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Committee on the Status of Endangered Wildlife in Canada

Comité sur le statut des espèces menacées de disparition au Canada

Ottawa, Ont. K1A 0H3
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STATUS REPORT ON THE CASCADE MANTLED GROUND SQUIRREL SPERMOPHILUS SATURATUS

IN CANADA

BY

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AND

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STATUS ASSIGNED IN 1992

NO DESIGNATION REQUIRED

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SPERMOPHILUS SATURATUS

IN CANADA

BY

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ABSTRACT

The Cascade mantled ground squirrel, *Spermophilus saturatus* is unique to the Cascade mountains of southwestern British Columbia and Washington State. It reaches the northern limit of its range in southern British Columbia where it is **uncommon** and its range fragmented. Three drainage systems surround this animal's range in British Columbia: The Fraser River to the west; the Nicola River to the north; and the Okanagan to the east. The latter also appears to form the western barrier of the more common golden mantled ground squirrel, *S. lateralis*, rendering the ranges of the two sibling species completely disjunct in Canada. *S. saturatus* was given species status based on its larger body size and less distinct lateral stripes compared to *S. lateralis*. Such classification has been substantiated recently by isozyme analysis and skull morphology comparisons. *S. saturatus* is on the provincial "red list" and is protected by the Wildlife Act S.B.C. 52/82.

S. saturatus is sedentary and is known to occupy krumholtz, talus slopes, closed coniferous forests, and open meadows where underground burrows can be built. Herbs are the main food during spring, while fungi are the main food in the fall. From mid-August to late September, hibernation begins and lasts about 7.5 months. It is not a colony breeder. First breeding may not occur until after an individual has survived two winters. The average litter size is four and only one litter is raised each year.

There are no good data on the demographic health or population size of *S. saturatus* in British Columbia. Two sizable provincial parks, Manning Park (66,500 ha) and Cathedral Park (33,000 ha), lie within the animal's range in the province. Since these areas are at present protected from resource extraction, they are potential refuges for the ground squirrel. The density of squirrels appears to be higher inside parks where supplemental food is available from park visitor handouts and refuse left by campers. The surveys of *S. saturatus* made in 1989 and 1990 indicate there may be a shift of the eastern boundary of its range westward, and may reflect the competitive exclusion of *S. saturatus* by the Columbian ground squirrel, *S. columbianus*.

Neither the population in British Columbia, nor the species as a whole seem to be at risk of imminent extinction. However, isozyme analysis of *S. saturatus* in British Columbia revealed that there is very little genetic variation in the population. This indicates, at least theoretically, that the population will not adapt to rapid changes in environmental conditions or extremes in random demographic variations. Since *S. saturatus* is at the northern limit of its range, it is likely that frequent local extinction and recolonization will take place, which may explain their sparse and unpredictable occurrence.

INTRODUCTION

In 1979, the Government of British Columbia formed a preliminary plan to designate threatened and endangered species in the province (Munro and Low 1979). Since then, regulations for non-game mammals have been improved by an Order-in-Council in May, 1990, whereby all native, non-game mammals acquired full protection on crown land under the official designation "wildlife". The lack of knowledge of many non-game species led to a listing of species most likely to be threatened or endangered. The Cascade mantled ground squirrel, *Spermophilus saturatus*, which is unique to the Cascade mountains of southwestern British Columbia and Washington State, is amongst the highest priority vertebrates (Red List) requiring study prior to a more formal designation as threatened or endangered.

GENERAL BIOLOGY

The Cascade mantled ground squirrel is the largest member (body length > 286 mm) of the subgenus *Callospermophilus*, which also includes *S. lateralis* and *S. madrensis*, a group of stocky golden brown squirrels with two lateral white stripes bordered by narrow dark stripes running from shoulders to rump (Howell 1938; Banfield 1974; Hall 1981). *S. saturatus* inhabits the Cascade Mountains of Washington State and British Columbia, a range that is thought to be disjunct from its more widespread sibling species, *S. lateralis* (Fig. 1). *S. saturatus* can be distinguished from *S. madrensis* by its larger size and having a poorly defined russet-coloured mantle on head and shoulders; in *S. madrensis* the mantle is almost completely lacking (Hall 1981). *S. saturatus* is less reliably distinguished from *S. lateralis* (Trombulak 1987).

1. Taxonomy:

The phylogeny of Nearctic Sciuridae, including *Callospermophilus*, has been described by Hafner (1984). Before the advent of techniques to measure genetic variation, *S. saturatus* was given species status based on its larger body size and less distinct lateral stripes compared to *S. lateralis* (Howell 1938, but also see Wright 1972). While this classification has been generally accepted (Honacki et al. 1982, Jones et al. 1986, and Nagorsen 1990), the genetic distance between *S. saturatus* and *S. lateralis* that would substantiate such classification has not been examined prior to the study of Leung (1991).

In Leung's (1991) study, *S. saturatus* and *S. lateralis* (subspecies *tesconum*) were captured with Tomahawk #201 live traps at four and six locations within their respective range (Fig. 2). The number of individuals sampled from each location ranged from 3 to 23, but as populations, a total of 48 *S. saturatus* and 46 *S. lateralis* were sampled, respectively. Standard horizontal starch gel electrophoresis techniques (May et al. 1979) were applied to the blood samples and activity was recorded for 24 presumptive gene loci. In addition to electrophoretic measurements, skull morphology of museum specimens of *S. saturatus* was also compared with those of the three subspecies of *S. lateralis*; *S. lateralis tesconum*, *S. l. chrysodeirus*, and *S. l. connectens*.

The electrophoretic data (Table 1) revealed that in two of the loci examined (PGD, PRO-2), there were alleles present in the *S. saturatus* samples that were not found in the *S. lateralis* samples, suggesting that *S. saturatus* is genetically distinct. Rogers' similarity (Rogers 1972) and Nei's distance (Nei 1978) detected a large enough difference to merit giving *S. saturatus* species status, especially when comparing it to *S. lateralis* from locations closest to *S. saturatus*. Significant differences were also found in the size and proportion of skulls between *S. saturatus* and the subspecies of *S. lateralis* (Table 2). *S. saturatus* was larger than *S. lateralis* for all cranial measurements. Within *S. lateralis*, *S.*

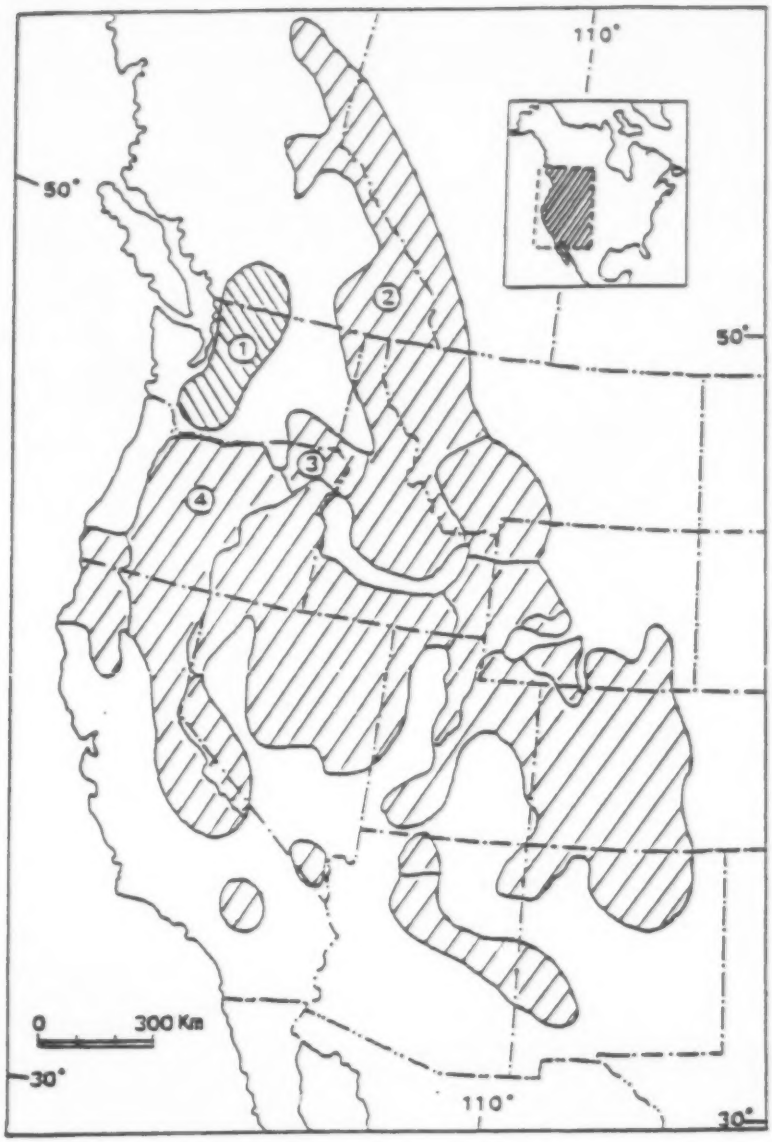

Fig. 1. The range of *Spermophilus saturatus* **and** *S. lateralis*. The subspecies of *S. lateralis* neighbouring *S. saturatus* (1) are: *S. lateralis tescorum* (2), *S. lateralis connectens* (3), and *S. lateralis chrysodeirus* (4). Figure from Hall (1981) with modifications.

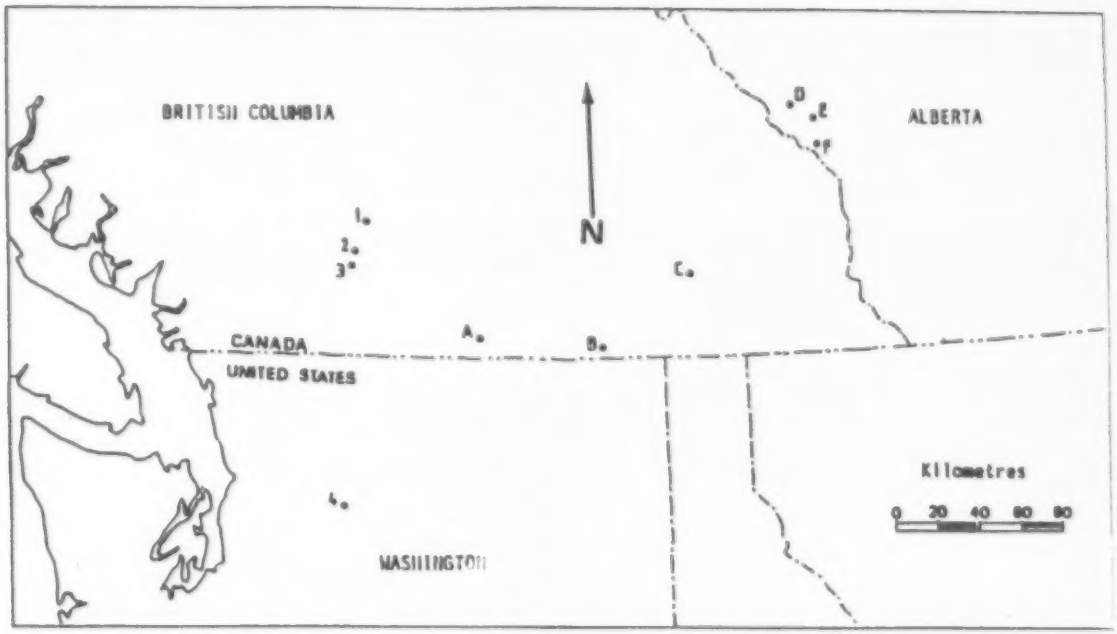

Fig. 2. Map of southwestern Canada and northwestern United States showing locations of blood sampling.

S. saturatus:
1. Iron Mountain 50°03'N 120°46'W
2. Brookmere Dump 49°49'N 120°52'W
3. Thynne Mountain 49°42'N 120°56'W
4. Lake Wenatchee 47°54'N 120°45'W

S. lateralis:
A. Mount Baldy 49°10'N 119°15'W
B. Rossland 49°05'N 117°49'W
C. Sphinx Mountain 49°37'N 116°39'W
D. West of Spray Lake 50°50'N 115°20'W
E. Limestone Mountain 50°51'N 115°10'W
F. Peter Lougheed Provincial Park 50°58'N 115°20'W

l. tescorum was consistently the largest of the three subspecies (Table 2).

Other morphological characteristics, including pelage colour and pattern can also distinguish *S. saturatus* from *S. lateralis* (Hall 1981). Warlsberg (1990) found significant differences in the pelage characteristics between *S. saturatus* and *S. lateralis* (from Arizona) by quantifying the solar heat gain of their coat layers and skin.

In conclusion, the presence of two alleles that only exist in *S. saturatus*, the genetic distance and the morphological differences between *S. saturatus* and *S. lateralis*, together with the disjunct range of *S. saturatus* that isolates it reproductively from *S. lateralis*, suggest that *S. saturatus* should be treated as a distinct species, separate from *S. lateralis*.

2. Reproductive Capability:

First breeding may not occur until after an individual has survived two winters. All adult males (i.e. 2 years or older) develop scrotal testes and all adult females (i.e. 2 years or older) breed. While a few yearling males may become scrotal, from 54% to 100% of yearling females breed. The average litter size is four and only one litter is raised each year (Kenagy and Barnes 1988). Michener (1983) placed *S. lateralis* in the least social of five categories describing sociality in ground-dwelling squirrels. Within the subgenus *Callospermophilus*, the only consistent cohesive and recognitive behaviours observed are mock fighting, smelling, and body contact among littermates or between young and mother in *S. lateralis* (Ferron 1985). *S. saturatus* is likewise asocial (Leung 1991).

Very little information is available concerning the age/sex ratio of its population structure in British Columbia. However, an age and sex composition estimate was provided by Leung (1991) after trapping at four locations (Fig. 2) of *S. saturatus* inhabitation in 1990. The mean age and sex composition of the 55 squirrels trapped (Fig. 3) was: adult female (31%), adult male (25%), yearling female (24%), yearling male (21%). Trombulak (1987) surveyed *S. saturatus* populations in forest and meadow habitats in Washington State between 1980 and 1982, and estimated the age/sex ratio as follows: Adult male (16%), yearling male (11%), Juvenile male (30%), adult female (12%), yearling female (13%), and juvenile female (18%). Sex ratio did not differ significantly from 1:1.

Trapping in three consecutive years (1980-1982) in Washington State showed that the density of *S. saturatus* was increasing during that period (Trombulak 1987), indicating that the population as a whole was at least not declining. Trapping in British Columbia in two consecutive years took place only at one location (Thynne Mountain) (Leung 1991). Here, of three adult females, four adult males, two yearling females and two yearling males (total of 11) marked in 1989, two adult females, two adult males, two yearling females, and one yearling male were recaptured in 1990. In addition, five new individuals were captured for the first time in 1990 (Fig. 3). In 1990, at least 5 adults and 2 young of the year were sighted at Coldspring Campground, Manning Park; at least 7 adults and 5 young of the year were sighted at Quiniscoe Campground/Resort Lodge, Cathedral Park (Leung & Cheng 1991). For rodents, mortality is usually the highest during the first year of life (Caughley 1977). The successful birth of young at the campgrounds and the overwinter survival of yearlings at Thynne Mountain indicate that there may be enough recruitment to replace mortality, at least at locations where supplemental food is available. The population in British Columbia, and the species as a whole seem not to have a high risk of imminent extinction.

Table 1. Allelic variation at eight polymorphic loci for *S. saturatus* and *S. lateralis* at different locations. See Fig. 2 for location codes.

		Locations of *S. saturatus*	Locations of *S. lateralis*					
		1,2,3,4	Combined A	B	C	D	E	F
Locus	Allele							
GPI	A	1.000	0.848	0.556	0.583	0.833	1.000	1.000	1.000
	B	0.000	0.152	0.444	0.417	0.167	0.000	0.000	0.000
NP	A	1.000	0.891	0.833	1.000	1.000	0.857	0.875	0.885
	B	0.000	0.109	0.167	0.000	0.000	0.143	0.125	0.115
PGD	A	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	B	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PEP-LGG	A	1.000	0.978	1.000	0.833	1.000	1.000	1.000	1.000
	B	0.000	0.022	0.000	0.167	0.000	0.000	0.000	0.000
EST-1	A	1.000	0.489	0.000	0.000	0.333	0.500	1.000	0.769
	B	0.000	0.511	1.000	1.000	0.667	0.500	0.000	0.231
PEP-GL-1	A	1.000	0.978	0.889	1.000	1.000	1.000	1.000	1.000
	B	0.000	0.022	0.111	0.000	0.000	0.000	0.000	0.000
PEP-GL-2	A	1.000	0.778	0.500	0.300	0.500	1.000	1.000	1.000
	B	0.000	0.222	0.500	0.700	0.500	0.000	0.000	0.000
PRO-2	A	0.000	0.593	0.944	0.750	0.500	0.571	0.286	0.500
	B	0.000	0.407	0.056	0.250	0.500	0.429	0.714	0.500
	C	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No. of samples		*48	46	9	6	3	7	8	13

* 48 is the sum of samples from: 1. Iron Mtn (7); 2. Brookmere Dump (23); 3. Thynne Mtn (11); 4. Wenatchee Lake (7).

Table 2. Differences in skull morphometric measurements* between *S. saturatus* (Ss) and the 3 subspecies of *S. lateralis*, *S. lateralis texcorum* (Slt), *chrysodeirus* (Slch), and *connectens* (Slco). Characters were measured in mm and the standard deviations are shown inside the brackets.

Character	Male				Female			
	Ss	Slt	Slch	Slco	Ss	Slt	Slch	Slco
Diastema length	11.62(0.63) a	10.98(0.55) b	10.30(0.49) b	10.55(0.57) b	11.32(0.60) a	10.88(0.57) ab	10.21(0.52) c	10.40(0.51) bc
Occipitonasal length	45.62(1.54) a	44.24(1.09) b	42.38(1.11) b	42.48(1.21) b	45.09(1.22) a	43.31(1.52) b	41.69(1.13) c	41.84(1.03) bc
Palatal length	21.09(0.65) a	20.22(0.73) b	19.58(0.62) b	19.40(0.59) b	20.77(0.66) a	20.06(0.84) b	19.12(0.66) c	19.16(0.57) bc
Zygomatic breadth	26.08(1.36) a	27.33(0.60) b	25.98(1.11) c	26.11(1.20) c	27.54(1.11) a	26.94(0.94) a	25.96(0.97) b	25.76(1.02) b
Mastoidal breadth	19.85(0.56) a	19.68(0.59) a	19.08(0.55) a	19.14(0.59) a	19.50(0.54) a	19.25(0.67) a	18.73(0.59) a	18.86(0.44) a
Interorbital constriction	11.17(0.54) a	10.59(0.54) b	9.92(0.34) c	9.65(0.59) c	11.00(0.72) a	10.32(0.49) b	9.77(0.45) bc	9.52(0.73) c
Nasal length	14.98(0.67) a	14.24(0.62) b	13.55(0.57) b	12.99(0.66) c	14.83(0.56) a	13.82(0.61) b	13.26(0.64) b	12.62(0.63) c
Maxillary tooth row	9.16(0.25) a	8.76(0.43) b	8.62(0.31) b	8.52(0.34) b	9.29(0.35) a	8.65(0.24) b	8.53(0.25) b	8.45(0.35) b
Cranial breadth	19.79(0.41) a	19.46(0.54) a	19.34(0.54) a	19.34(0.45) a	19.45(0.52) a	19.31(0.53) a	19.01(0.57) a	18.90(0.40) a
Postorbital constriction	13.30(0.42) a	12.76(0.56) b	12.96(0.47) b	12.62(0.75) b	12.97(0.64) a	12.65(0.34) b	12.45(0.45) b	12.59(0.59) b
N=	43	27	13	13	37	15	38	11

* Within each sex, means for a character followed by the same letter were not different, means followed by different letters were significantly different ($P<0.05$) by the LSD Multiple Range Test.

3. Species Movement:

S. saturatus is sedentary and is known to occupy high elevation krumholtz, talus slopes, open meadows where underground burrows can be built, and adjacent closed sub-alpine coniferous forests (Reichel 1986; Trombulak 1988). During spring, herbs are the main food while fungi are the main food in fall (Kenagy 1987). From mid-August to late September, hibernation begins and lasts about 7.5 months (Trombulak 1988).

In Washington State, distance of juvenile dispersal from their natal burrows is affected by habitat (Trombulak 1983); mean dispersal distance in forested habitat was 54.8 m whereas in meadow habitat it was 231.0 m. Both males and females tend to disperse from the natal burrow; males dispersed an average of 181.8 m and females dispersed 157.5 m (Trombulak 1987). No data is available for *S. saturatus* populations in British Columbia.

4. Protection of areas of concentration:

Two sizable provincial parks, Manning Park (66,500 ha) and Cathedral Park (33,000 ha), lie within the range of *S. saturatus* in British Columbia. Since these areas are protected from resource extraction (at least under present regulations), they are potential refuges for the ground squirrel.

HABITAT

Booth (1947) found *S. saturatus* to be common on eastern slopes of the Cascade Mountains from alpine to yellow pine (*Pinus ponderosa*) belts but rarely on western slopes. In alpine habitat the squirrels are primarily found in krumholtz and areas where talus $\geq$ 75% of the total cover (Reichel 1986). Individuals can be found among scattered yellow pines above sage (*Artemisia tridentata*) and grassland at 1,000 m, but rarely in the open away from the cover of trees and logs (Broadbooks 1958). At 800 m they are found in closed coniferous forests as well as open meadows and clearcuts (Trombulak 1987).

Within these habitats, the squirrels meet their basic food and shelter requirements. The diet of *S. saturatus* includes the genera *Achillea*, *Draba*, *Epilobium*, *Erigeron*, *Erythronium*, *Fragaria*, *Gaultheria*, *Lupinus*, *Oxytropis*, *Penstemon*, *Phacelia*, *Phlox*, *Pinus*, *Rhizopogon*, *Senecio*, *Silene*, *Sorbus*, *Taraxacum*, *Trifolium*, *Vaccinium*, *Vicia*, bark, corms, fungi and hypogeous fungi (Dalquest 1948; Broadbooks 1958; Trombulak 1988; Cork and Kenagy 1989; Leung 1991). *S. saturatus* constructs burrows for shelter and protection from predators.

Perches for vigilance (MacHutchon and Harestad 1990) could also be essential components of *S. saturatus* habitat since these squirrels spend most of their above-ground time sitting (Trombulak 1987). Potential predators of *S. saturatus* include the great-horned owl (*Bubo virginianus*), goshawk (*Accipiter gentilis*), red-tailed hawk (*Buteo jamaicensis*), merlin (*Falco columbarius*), long-eared owl (*Asio otus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), long tailed weasel (*Mustela frenata*), marten (*Martes americana*) and bobcat (*Lynx rufus*) (Trombulak 1988). None of these predators are known to depend primarily on the squirrel for food.

S. saturatus habitats in British Columbia were assessed between 24 June and 23 July 1990 (Leung 1991). In addition to the more general parameters noted in previous reports (Booth 1947; Reichel 1986; Trombulak 1987), the percent cover of plant and unvegetated categories at nine locations inhabited by the squirrels were also measured, beginning with the locations of earliest plant phenology. The nine locations were differentiated into five where food was not supplemented (Cathedral Park Slope, Cathedral Lakes Provincial Park 49°05'N 120°12'W; Iron Mountain 50°03'N 120°46'W; Ladyslipper Lake, Cathedral Lakes Provincial Park 49°03'N 120°11'W; Mount Outram 49°17'N

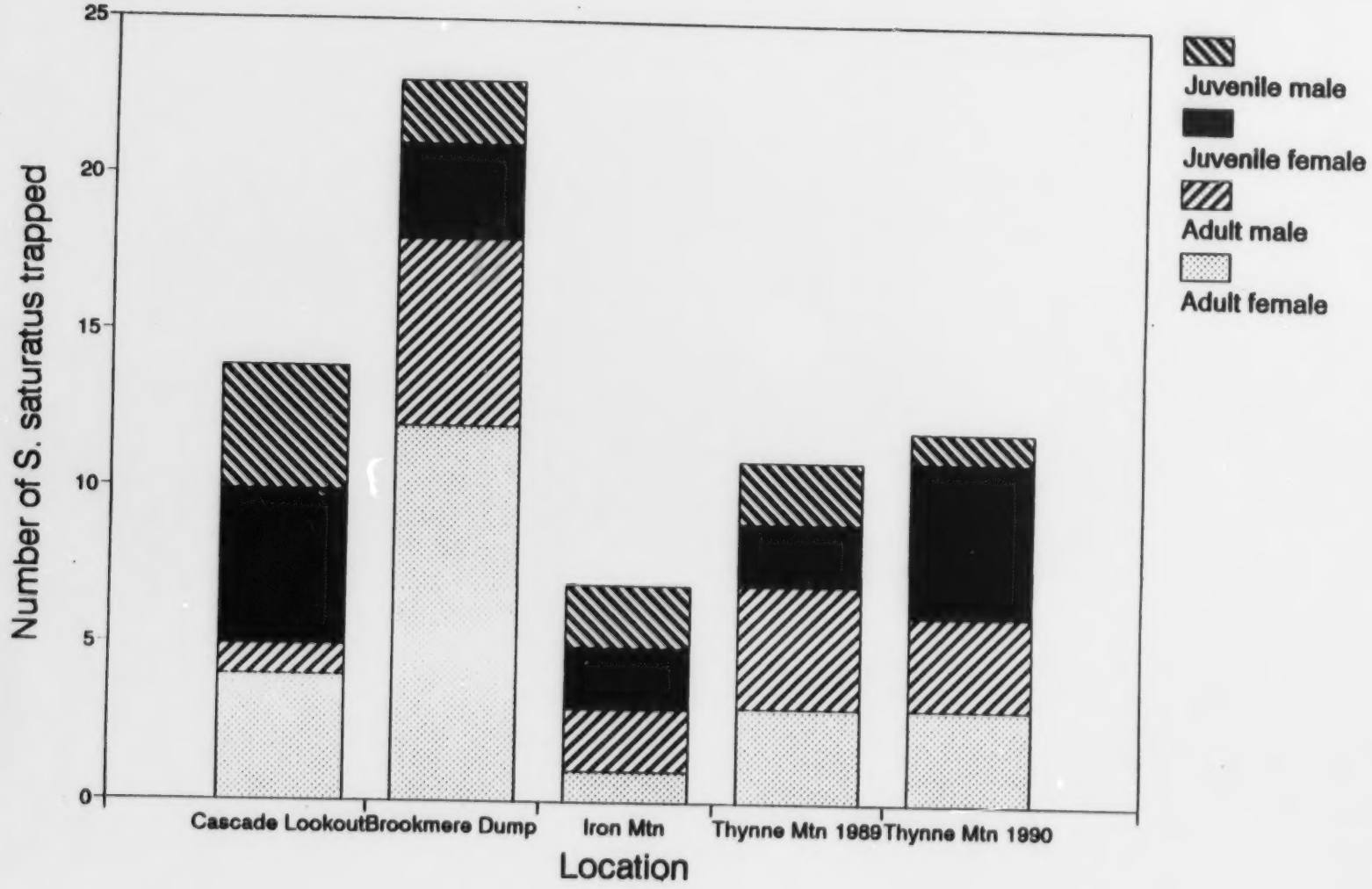

Fig. 3. Age and sex composition of S. saturatus at four locations. CL & BD = 80 trapping days each; IM & TM = 120 trapping days each.

121°10'W; Thynne Mountain 49°42'N 120°55'W) and four where food was supplemented by visitor handouts and refuse (Brookmere Dump 49°49'N 120°52'W; Coldspring Campground, Manning Provincial Park 49°05'N 120°48'W; Cascade Lookout, Manning Provincial Park 49°05'N 120°48'W; Quiniscoe Campground, Cathedral Lakes Provincial Park 49°04'N 120°12'W). The mean percent cover and standard deviations of the perceived functional components for each location are summarized in Table 3.

From data presented, *S. saturatus* habitat in British Columbia seemed less predictable compared to those previously reported (Booth 1947; Broadbooks 1958; Reichel 1986; Trombulak 1987) for its conspecifics in Washington State. It is known that some vertebrate species (eg. birds) were less selective of vegetational characteristics at the northern edge as opposed to the southern portion of their range (Eeva et al. 1989).

While a final conclusion cannot be drawn until statistical analyses can be applied to the data collected, no single perceived functional component seemed to consistently dominate the nine locations sampled, nor was there any apparent difference between the food supplemented and non-food supplemented locations. The lack of consistency in the composition of functional components at various locations may reflect a great flexibility in the diet of *S. saturatus*. The hypogeous fungi and plant genera ingested by *S. saturatus* also appear in food items listed for its sibling species, *S. lateralis* (Tevis 1954, McKeever 1964, Carlton 1966). *S. lateralis* is known to have a wide range of foods in its diet; the same is probably true for *S. saturatus*. Trombulak (1987) found that forest dwelling and meadow dwelling *S. saturatus* had different diets reflecting the availability of different foods. To better assess the food availability at a location, more information on the variety of food species required to satisfy *S. saturatus* of different age and sex groups over different seasons is needed (see also Cork and Kenagy 1989).

In the habitat assessment by Leung (1991), the functional components were measured and compared among locations without taking into account the different densities of squirrels in each location. If the number of squirrels utilizing a location is known, it may be easier to determine whether a particular functional component is a limiting factor (e.g. see Carl 1971 and Young 1990, re: burrowing sites limiting population sizes of some *Spermophilus* spp.).

Further studies should also include comparisons of occupied locations with unoccupied adjacent locations. The daily activity pattern of individual *S. saturatus* should be followed to determine which habitat characteristics permit *S. saturatus* inhabitation and which of these habitat characteristics are absent in adjacent unoccupied sites. A better comparison of *S. saturatus* habitat at different parts of its range is only possible if similar surveying techniques are applied to habitat across its range. Habitat descriptions should include the role of competitors for the same resources and the role of predator reliance on *S. saturatus* as prey, since predators could change the suitability of habitat for the ground squirrel.

Leung & Cheng (1991) concluded that habitat may not be the primary factor restricting the squirrel's distribution, as within the range of its distribution, many locations of seemingly suitable habitat appeared unoccupied.

DISTRIBUTION

S. saturatus is unique to the Cascade mountains of southwestern British Columbia and Washington State (Fig. 1), along with other taxonomic groups such as the Cascade frog (*Rana cascadae*; Nussbaum et al. 1983) and the Cascade fox (*Vulpes vulpes cascadensis*; Hall 1981). Little is known about the squirrel's Northern limit in British Columbia (Trombulak 1988)

Table 3. Percent cover of functional components. Values rounded off to nearest integer.

	No. of plots		Herb Layer			Shrub Layer				Tree Layer	
			Plant cover	Food spp.	Burrow potential	Protective cover	Food spp.	Conifers	Perches	Protective cover	Conifers
Supplemented food sites											
Brookmere Dump	25	mean	43	11	54	39	11	1	1	19	18
		sd	23	18	24	34	18	4	3	18	18
Coldspring Campground	10	mean	58	39	39	64	10	5	0	54	54
		sd	20	18	19	21	14	11	0	27	27
Cascade Lookout	15	mean	40	30	32	35	3	6	7	28	27
		sd	28	18	28	35	5	12	18	28	27
Quinlacoe Campground	25	mean	31	40	53	17	0	14	10	41	41
		sd	21	14	25	17	1	15	14	28	28
Natural food sites											
Cathedral Park Slope	10	mean	63	40	16	33	0	2	22	27	27
		sd	31	24	12	28	1	5	33	27	27
Iron Mountain	25	mean	60	19	20	33	6	1	5	28	27
		sd	21	14	13	23	10	2	10	28	28
Ladyslipper Lake	10	mean	79	35	13	23	1	9	14	0	0
		sd	9	6	8	21	2	14	7	0	0
Mount Outram	25	mean	71	18	12	4	1	2	0	9	8
		sd	25	12	7	8	4	4	0	19	19
Thynne Mountain	25	mean	52	24	37	28	2	9	4	10	10
		sd	21	17	24	23	4	11	9	17	17

except for data presented in Hall (1981), Howell (1938), and Leung (1991).

The former and current (Leung 1991) range and distribution of the squirrel in British Columbia is shown in Fig. 3.1. Historical museum records of *S. saturatus* in B.C. are summarized in Appendix 1. Coordinates for locations where *S. saturatus* was sighted by Leung (1991) and their corresponding letters in Fig. 3.1 are listed in Appendix 2, along with their respective biogeoclimatic zone, altitude, and method of survey by which the squirrel was detected. The locations, their respective biogeoclimatic zone and altitude, where no *S. saturatus* was detected by observation, and their corresponding numbers in Fig. 3.1, are listed in Appendix 3.

Rivers are obvious potential boundaries to small terrestrial mammals such as *S. saturatus* and three drainage systems surround its range in British Columbia. To the west is the Fraser River; to the north is the Nicola River system; and to the east is the Okanagan system. The latter also appears to form the western barrier of *S. lateralis*, rendering the ranges of the two sibling species completely disjunct in Canada. The two are not known to overlap elsewhere (Hall 1981).

Glaciers, and subsequent drainage patterns, could have isolated members of the subgenus *Callospermophilus* (Howell 1938) into several refugia during or following the Pleistocene. *S. saturatus* probably spread northward into British Columbia from the southern Cascade Mountain Range after the retreat of the Cordilleran Ice Sheet. These glaciers covered most of southern British Columbia and extended as far as the Puget Inlet in Washington State 17,500 B.P. (Fulton et al. 1986). The Skagit Valley that separates the population of *S. saturatus* near William's Peak (Location AC in Fig. 3.1 and Appendix 2) from the other locations of *S. saturatus* in British Columbia suggests this historical dispersal. *S. saturatus* at William's Peak probably colonized from the south and not from the east.

Betts (1990) and Tomich (1982) suggest that the present distribution of other *Spermophilus* species is affected by past epidemics of plague (*Yersinia pestis*). At the turn of the century, plague that originated from Yunnan province in China, was introduced into wild populations of mammals in United States from non-native rats via fleas (Mitchell 1966). The plague bacillus was found in *S. lateralis*, the sibling species of *S. saturatus*, in western United States. Dieoffs of ground squirrel colonies were observed and although this was not seen with *S. lateralis* or *S. saturatus*, they are susceptible hosts (Stark et al. 1966). The fleas identified from *S. saturatus* during Leung's (1991) survey were *Oropsylla idahoensis* which may maintain sylvatic plague in ground squirrel populations (Lewis et al. 1988). Since historical accounts are not available, the role of disease on the distribution of *S. saturatus* cannot be substantiated.

POPULATION SIZE AND TREND

1. Population size:

There has not been any serious attempt to estimate the actual number of *S. saturatus* in British Columbia. Within its habitats in Washington State, Trombulak (1983) estimated 4.5 individuals/ha in open meadows and 2.0/ha in closed coniferous forest. Along the talus embankments of railroads, Dalquest (1948) estimated one squirrel/90 m. In British Columbia, the density of squirrels in locations where supplemental food is available is higher than Trombulak's (1983) estimates, and seems to be less than estimated in other locations (Leung 1991). Leung & Cheng (1991) concluded that *S. saturatus* are uncommon within their range in British Columbia, with the exception of certain locations in Manning Park and Cathedral Park. The higher density of squirrels in these locations is probably because of food supplements.

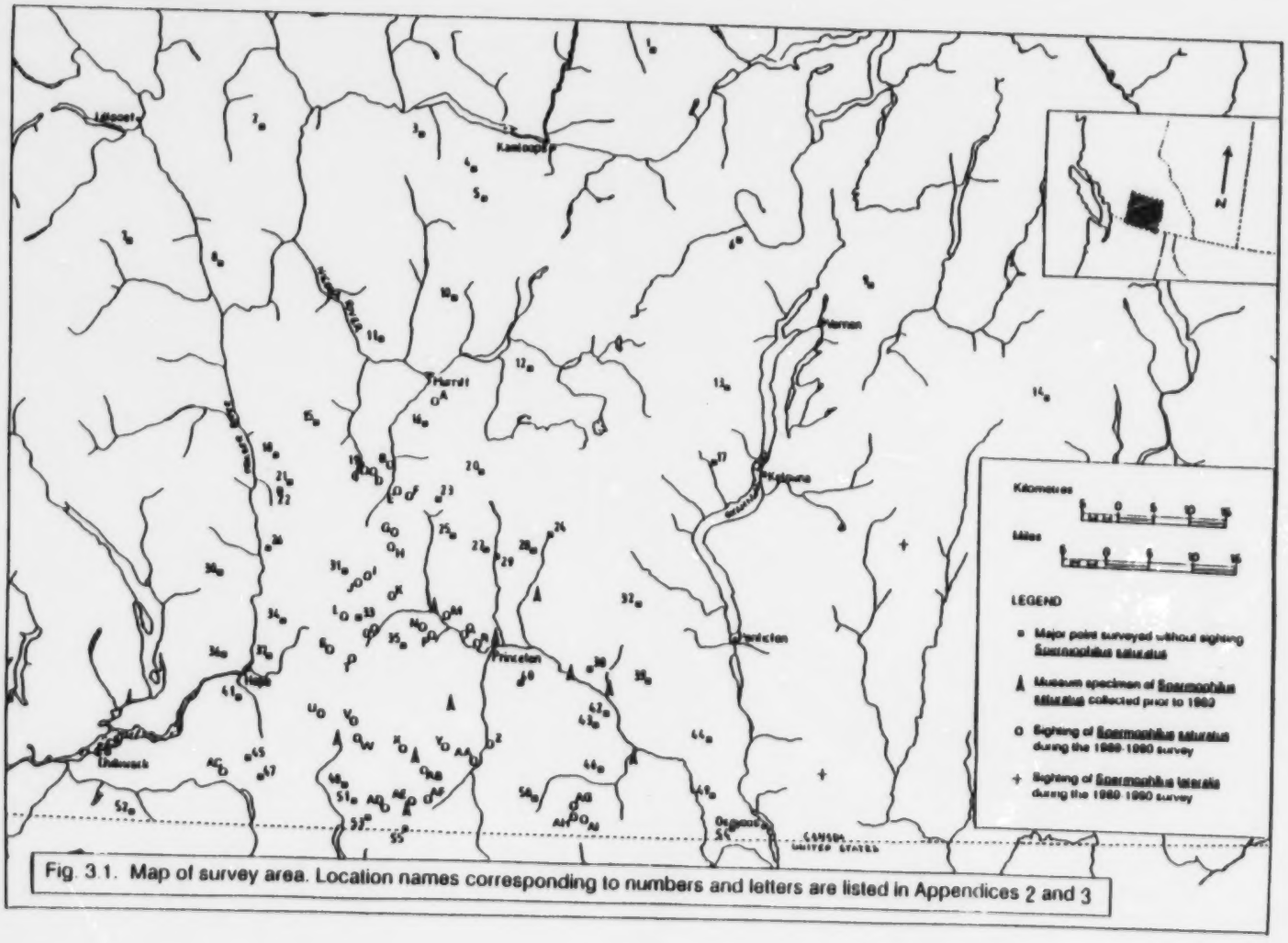

Fig. 3.1. Map of survey area. Location names corresponding to numbers and letters are listed in Appendices 2 and 3

2. Range shifts and extension:

The surveys of *S. saturatus* made in 1989 and 1990 indicate that its range in British Columbia is further north and west than documented by museum specimens (Fig. 3.1). The increased range extension northward and westward found during these surveys probably reflects enhanced human access to these areas, rather than a true range expansion by the squirrel. While the shift of the eastern boundary westward may only be apparent due to inadequate sampling effort around the eastern boundary, Leung (1991) considered it more likely to be real and reflected the competitive exclusion of *S. saturatus* by the Columbian ground squirrel, *S. columbianus*.

In British Columbia, *S. saturatus* has been known to reside in Manning Park since its designation in 1941, but *S. columbianus* was first observed only after the construction of the highway traversing the park (Ted Underhill, pers. comm.). Leung (1991) and David Nagorsen (pers. comm.) argued that roads built during this century facilitated the westward dispersal of *S. columbianus*, either by creating corridors of suitable habitat or by vehicles unknowingly transporting the animals to suitable habitat.

Evidence of competitive exclusion has been observed between *S. lateralis* and *S. columbianus* in Rossland, British Columbia. At one site where all *S. columbianus* were removed, *S. lateralis* subsequently inhabited the area (Leung 1991). If interference competition does occur, the larger size of *S. columbianus* (340-812 g) compared to *S. saturatus* (170-276 g) (Burt and Grossenheider 1976) would probably put the latter at a major disadvantage. In meadow habitat, *S. columbianus*, with its cooperative and colonial social system, could out-compete *S. saturatus*, with its solitary behaviour (Michener 1983). Besides shifting the range boundary of *S. saturatus*, *S. columbianus* may also affect the distribution of *S. saturatus* populations within its range. *S. saturatus* had previously been sighted in the alpine meadows at Blackwall Peak in Manning Park, but Leung's survey in 1991 found the same location occupied by a *S. columbianus* colony.

3. Genetic variations:

Of the 24 presumptive gene loci examined electrophoretically (Leung 1991), eight were polymorphic in *S. lateralis* populations but all were fixed for the same alleles in all of the *S. saturatus* sampled (Table 1). This lack of genetic variation in *S. saturatus* populations has two important theoretical implications:

a. Inbreeding depression is sometimes associated with a lack of genetic variation (Franklin 1980) and has been a cause of concern for several endangered species including cheetahs *Acinonyx jubatus* (O'Brien et al. 1983) and golden lion tamarins, *Leontopithecus rosalia* (Ralls and Ballou 1986). When genetic variation is reduced, the population will be less adaptive to changing environmental conditions and demographic variability (Gilpin and Soule 1986; Lande 1988). This lack of genetic variation may also limit the distribution of *S. saturatus* in the northern edge of its range. Isozyme analysis has a lower resolution for identifying genetic variation than DNA fingerprinting techniques (Chambers and Bayless 1983; Ayala and Kiger 1984), the application of which in future surveys could provide more insight on the genetic characteristics of *S. saturatus* over its range. It is also important to obtain more samples from populations in Washington State for comparison. Kenagy (unpubl. data) examined the same 24 loci in *S. saturatus* from the Lake Wanatchee area and found GPI, LDH, and EST-1 to be polymorphic in that population.

b. The lack of genetic variation cannot be explained by habitat loss for the same reason as noted in the spotted owl, *Strix occidentalis* (Barrowclough and Gutierrez 1990). The number of

generations required to reduce genetic variation by reducing population size exceeds the length of time since habitat loss began (Nei et al. 1975). Besides, habitat fragmentation would cause genetic homogeneity in isolated locations, but would allow variability between locations. It is more likely that at the northern limit of the range of *S. saturatus*, with marginal habitat and climatic conditions, its populations are experiencing frequent local extinction and recolonization, with the exception of perhaps the food supplemented locations. The few food supplemented locations may support small but more stable populations which are the source of new recruits for other locations. It is, therefore, crucial to conduct more genetic surveys to determine if this is indeed the scenario, and also to estimate the rate of recruits coming from further south.

LIMITING FACTORS

From the information gathered, it seems that factors limiting the distribution and density of *S. saturatus* in British Columbia are not habitat loss, environmental contamination, or predation, but likely species competition and genetic homozygosity. However, both factors have to be examined more carefully before final conclusions can be drawn. Small mammals tend to be more vulnerable to exposure during weather extremes (Bailey 1986). Colder average temperatures further north may limit the reproductive season of the squirrel to the point where juveniles are unable to grow enough to survive through their first winter. Such decrease in reproduction may limit their northern distribution (Bronson 1979, Philips 1984). The demographic health of *S. saturatus* in British Columbia cannot be determined from present information. It is likely that being at the northern limit of its range, frequent local extinction and recolonization may explain its sparse and unpredictable occurrence.

Park visitors express their desire to view and interact with the squirrels at close range by feeding them. While the higher density of squirrels in these locations may be attributable to the food supplements, the feeding interaction in itself creates problems (Leung & Cheng 1991). Squirrels habituated to handouts of human food will pilfer food uninvited and cause damage to camping gear. this is potentially harmful to both parties involved if unregulated.

SPECIAL SIGNIFICANCE OF THE SPECIES

As mentioned in the introduction, *S. saturatus* is on the provincial red list as potentially threatened or endangered. The species is found only in B.C. and nowhere else in Canada. Unless further studies show that the population in British Columbia is isolated from populations further south and is showing genetic divergence, this taxonomic unit seems secure. The squirrel is a non-game species. The primary justification for its conservation would be maintaining the biodiversity of species within the province (and Canada).

RECOMMENDATIONS/MANAGEMENT OPTIONS

1. Research priorities:

a. Further examination of the genetic variation of *S. saturatus* in Washington State in comparison with that of *S. saturatus* in British Columbia.

b. Obtain information on population structure and trend of *S. saturatus* in Britis' Columbia for better assessment of its demograpic health. (Age/sex ratio, birth rates, and age specific mortality)

c. Determine the dispersal and colonizing ability of *S. saturatus* in British Columbia for better assessment of its demograpic health.

d. Further examine the food and habitat requirements of *S. saturatus* across its range

in British Columbia.

e. Explore the potential of parks and other forms of reserves functioning as reserves for *S. saturatus*. A "GAP" analysis (Nagorsen, pers. comm.) superimposing the boundaries of the provincial parks and other protected areas on the distribution of known *S. saturatus* localities would reveal the percentage of the presumed range of the species in B. C. that is actually enclosed in protected areas.

f. Determine if habitat alteration promotes the expansion of the range of *S. columbianus* and if there is exploitative competition between *S. saturatus* and *S. columbianus* whereby *S. saturatus* is displaced.

2. Recommendations:

Both Manning Park and Cathedral Park have locations of relatively high density *S. saturatus* inhabitation. Since the ground squirrels are uncommon within their range in British Columbia, parks offer a unique opportunity for the public to view the squirrel and can function as part of a reserve' system for their population (see points 1.e. and 1.f., this section). Records of *S. saturatus* sightings should be kept as part of a monitoring program. The land surrounding parks needs to be considered for dispersal corridors. Recreation is compatible with squirrels in the park if visitor use is regulated. Improved public education is required to minimize the problem of unwanted squirrel behaviour. Efforts to increase natural food abundance in the park may also help to minimize this problem.

EVALUATION

For the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the technical definition of species includes "any species, subspecies, or geographically separated population". *S. saturatus* fits this definition because its genetic composition and morphology are sufficiently different from its closest relative, *S. lateralis*, and its geographic range is disjunct from *S. lateralis*.

COSEWIC defines a "vulnerable species" as "any indigenous species of fauna or flora that is particularly at risk because of low or declining numbers, occurrence at the fringe of its range or in restricted areas, or for some other reason, but is not a threatened species" (Munro 1990). Clearly, by this definition, *S. saturatus* in British Columbia fits into the category of "vulnerable species" because it is at the northern "fringe" of its range. Although the range of *S. saturatus* is further west and north than previously cited, data suggest that this squirrel is not common anywhere in British Columbia (Leung 1991). *S. saturatus* is not found as far east as was previously reported, possibly due to habitat alteration and subsequent displacement by competing species (Leung 1991).

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APPENDICES

Appendix 1: Museum records of *S. saturatus* in British Columbia.
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Appendix 2: Locations where *S. saturatus* were sighted in British Columbia.

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Appendix 3: Locations where no *S. saturatus* was sighted in British Columbia. (with key to biogeoclimatic zones attached).
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(**Key to biogeoclimatic zones**...p.27)

APPENDIX 1: Museum records of S. saturatus in British Columbia

Species	Sex	Location	Museum	ID#	Date
Ss	f	Manning Prov. Park, BC	UBC	2968	1949
Ss	f	Princeton, BC	UBC	3685	1943
Ss	f	Manning Prov. Park, BC	UBC	2969	1949
Ss	f	Princeton, BC	UBC	3683	1943
Ss	f	17 miles up Ashnola R., BC	UBC	5629	1950
Ss	f	Kittitas Co., WA	UBC	667	1937
Ss	f	Ashnola R., BC	UBC	3556	1951
Ss	m	Ashnola Forks, BC	UBC	3554	1951
Ss	m	Ashnola Forks, BC	UBC	3555	1951
Ss	m	Gibson Pass, Manning Prov. Park, BC	UBC	4298	1952
Ss	m	Princeton, BC	UBC	3684	1943
Ss	m	Blue R.(northnortheast of Princeton), BC	UBC	5630	1947
Ss	m	Manning Prov. Park, BC	UBC	2966	1949
Ss	m	12 miles East of Princeton, BC	UBC	5631	1952
Ss	f	Second Summit, Skagit R., BC	NMC	1207	1905
Ss	f	Similkameen R., BC	NMC	8966	1928
Ss	f	Second Summit, Skagit R., BC	NMC	1198	1905
Ss	f	Ashnola Ck, BC	NMC	28847	1950
Ss	f	Similkameen R., BC	NMC	8967	1928
Ss	f	Hope-Princeton Summit Pass, BC	NMC	7858	1927
Ss	f	Hope-Princeton Summit Pass, BC	NMC	7856	1927
Ss	f	Stirling Ck (Northwest of Hedley), BC	NMC	8884	1928
Ss	f	near Princeton, BC	NMC	28848	1950
Ss	f	Stirling Ck (Northwest of Hedley), BC	NMC	8883	1928
Ss	f	Stirling Ck (Northwest of Hedley), BC	NMC	8908	1928
Ss	f	Second Summit, Skagit R., BC	NMC	1199	1905
Ss	f	Stirling Ck (Northwest of Hedley), BC	NMC	8857	1928
Ss	m	Second Summit, Skagit R., BC	NMC	1206	1905
Ss	m	Whipsaw Ck, BC	NMC	1163	1905
Ss	m	Skagit, BC	NMC	1165	1905
Ss	m	Second Summit, Skagit R., BC	NMC	1202	1905
Ss	m	Hope-Princeton Summit Pass, BC	NMC	7857	1927
Ss	m	Stirling Ck (Northwest of Hedley), BC	NMC	8886	1928
Ss	-	Manning Prov. Park, BC	RBCM	5175	1945
Ss	-	Mt Gordon, Manning Prov. Pk, BC	RBCM	5485	1949
Ss	-	Tulameen, BC	RBCM	225	1917
Ss	-	Princeton, BC	RBCM	4956	1939
Ss	-	Princeton, BC	RBCM	4955	1939
Ss	-	Manning Prov. Park, BC	RBCM	5174	1945

Appendix 2. Locations where S. saturatus were sighted in British Columbia. Each sighting's respective altitude, method of survey by which the animal was detected, and biogeoclimatic zone are given (key follows Appendix3). Methods of survey: F = survey form; R = road/opportunistic sighting; O = observation with time to first sighting in parentheses.

Location/coordinates	Altitude	Survey method	Biogeoclimatic zone
A. Iron Mtn 50°03'N 120°46'W	1650	O(60)	MSxk
B. Gillis Lake cattleguard 49°44'N 120°55'W	950	R	-
C. W of Gillis Lake 49°54'N 121°02'W	800	R	-
D. Gillis Mtn 49°54'N 120°59'W	1550	O(31)	ESSFdcp
E. W of Brookmere 49°50'N 120°54'W	1000	R	IDFdk
F. Brookmere Garbage Dump 49°49'N 120°52'W	1000	O(5)	IDFdk
G. N of Thynne Mtn 49°46'N 120°55'W	1450	R	ESSFdc
H. Thynne Mtn 49°42'N 120°55'W	1950	O(72)	ESSFdcp
I. S of Coquihala Lakes 49°38'N 121°00'W	1100	R	ESSFwm
J1. 4 km SW of Coquihala Lakes 49°36'N 121°04'W	1000	R	-
J2. 8km SW of Coquihala Lakes 49°35'N 121°06'W	1000	R	-
K. N of Grasshopper Mtn 49°35'N 120°54"W	1250	R	MSdm, ESSFwm
L. W of Needle Peak 49°34'N 121°07'W	1500	F	-
M. NW of Coalmont 49°32'N 120°43'W	800	R	IDFxh
N. road to Lodestone Lake 49°30'N 120°46'W	?1350	F	MSdm
O. N of Tulameen River 49°29'N 120°59'W	1000	R	MS
P. Blackburn Road 49°29'N 120°44'W	1250	O(31)	IDFdk
Q. between Coalmont and Princeton 49°30'N 120°39"W	800	F	-
R. NWW of Princeton 49°28'N 120°37'W	700	R	IDFdk

Appendix 2. Continued.

Location/coordinates	Altitude	Survey method	Biogeoclimatic zone
S. NE of Mt Snider 49°26N 121°07'W	1200	O(54)	AEp, Mb
T. Treasure Mtn 49°25'N 121°03'W	1700	O(49)	-
U. Mt Outram 49°17'N 121°10'W	1800-2100	O(31)	AEp
V. 3km N of Dry Lake 49°17'N 121°02'W	1200	F	-
W. W end of Manning Park 49°13'N 121°01'W	1000	F	-
X. Kicking Horse Campground, Manning Park 49°11'N 120°49'W	1900	F	AEp
Y. Garison Lake 49°13'N 120°41'W	1300	F	MSdm
Z. E of Copper Creek 49°15'N 120°46'W	1000	R	IDFdk
AA. 8 km E of Manning Park 49°11'N 120°33'W	1050	R	IDFdk
AB. First Brother Mtn 49°05'N 120°46'W	2250	O(53)	AEp
AC. William's Peak 49°07'N 121°30'W	1900	O(45)	Mb
AD. Strawberry Flats, Manning Park 49°04'N 120°53'W	1400	O(35)	Ef
AE. Coldspring Campground, Manning Park 49°05'N 120°48'W	1250	O(5)	IFu
AF. Cascade Lookout, Manning Park 49°04'N 120°46'W	1750	O(1),F	Ee
AG. Resort Lodge, Cathedral Park 49°04'N 120°12'W	2100	O(1)	ESSFxc
AH. N of Ladyslipper Lake, Cathedral Park 49°03'N 120°11'W	2250	O(44)	ATExcp
AI. Lakeview Mtn 49°02'N 120°09'W	2500	O(31)	ATExcp

Appendix 3. Locations surveyed where no S. saturatus was sighted. The respective altitudinal ranges, number of hours spent observing, and biogeoclimatic zones are included (key follows this table).

Location/coordinates	Altitude range	Observation hours	Biogeoclimatic zone
1. Mt Todd 50°55'N 119°56'W	2100	5	-
2. Cornwall Hills 50°42'N 121°28'W	2000	2	-
3. Mt Savona 51°42'N 120°49'W	1500	3	-
4. Greenstone Mtn 50°37'N 120°38'W	1800	3	-
5. Chuwels Mtn 50°32'N 120°4'W	1900	4	-
6. Tuktakamin Mtn 50°28'N 119°34'W	1800	4	MSdm
7. N of Devil's Lake 50°25'N 121°53'W	1700 -2100	10	-
8. Botanie Mtn 50°20'N 121°36'W	1400 -1900	6	-
9. Silverstar Mtn 50°22'N 119°03'W	1600 -1850	6	ESSFdc
10. Swakum Mtn 50°18'N 120°42'W	1700	3	MSxk
11. Promontory Hills 50°12'N 120°58'W	1000, 1700	4	MSxk
12. Mt Hamilton 50°08'N 120°21'W	1500	2	IDFdk
13. Terrace Mtn 50°06'N 119°37'W	1600 -1900	6	ESSFxc
14. Eureka Mtn 50°05'N 118°23'W	1900	2	-
15. Stoyoma Mtn 49°59'N 121°13'W	2200	5	-
16. Kane Valley Trail 49°49'N 120°44'W	1350	10	IDFdk
17. Carrot Mtn 49°45'N 119°39'W	1500	6	MSdm
18. E of Boston Bar 49°54'N 121°23'W	1100	1	Ef, AMp
19. W of Gillis Lake 49°55'N 121°05'W	1300	3	-
20. Bluey Lake 49°52'N 120°35'W	1100	2	IDFdk
21. SE of Boston Bar 49°39'N 121o22'W	800	2	Hb
22. Uztimus Rd 49°47'N 121°20'W	500	1	Hc, Hb

Appendix 3. Continued.

Location/coordinates	Altitude range	Observation hours	Biogeoclimatic zone
23. 8km E of Brookmere 49°49'N 120°40'W	1100	1	-
24. Siwash Lake Rd 49°43'N 120°21'W	1250	3	IDFdk
25. Mt Pike 49°43'N 120°40'W	1400	8	MSdm
26. SE of Boston Bar 49°40'N 121°24'W	500	2	Hb
27. Missezula Mtn 49°40'N 120°32'W	1500	6	ESSFdc, MSdm
28. Chain Lake 49°44'N 120°19'W	1350	2	MSdm
29. Rampart Lake 49°39'N 120°30'W	1400	2	IDFdk
30. N of Spuzzum Creek 49°38'N 121°34'W	1000	4	Mb, AMp
31. Douglas Lake Trail 49°38'N 121°08'W	1300	4	-
32. Isintok Mtn 49°34'N 119°58'W	1800	5	MSdm
33. E of Needle Peak 49°34'N 121°06'W	1500	5	Hb, Mb
34. Emancipation Mtn 49°30'N 121°16'W	1100	5	AMp, Mb
35. Lodestone Mtn 49°28'N 121°50'W	1850	6	ESSFdcp
36. Dog Mtn 49°24'N 121°32'W	1000	2	Ma, Hb
37. Oglivie Mtn 49°25'N 121°23'W	750 -1000	14	AMp, Mb
38. Stemwinder Rd 49°25'N 120°09'W	1400	4	IDFdk
39. Apex Mtn 49°28'N 119°55'W	2200	7	ESSFxcp
40. Agate Mtn 49°23'N 120°24'W	1600	4	MSdm
41. S of Eureka Creek 49°20'N 121°28'W	500 -900	10	Hb, Mb
42. Whistle Creek Rd 49°18'N 120°06'W	1600	6	IDFdk, MSxk
43. NW of IR10 49°16'N 120°09'W	2000	6	IDFdk, MSxk
44. Orofino Peak 49°15'N 119°41'W	1500	3	IDFdk
45. Yola Creek 49°11'N 121°26'W	1000	3	Hb, Mb
46. Crater Mtn 49°11'N 120°05'W	2000 -2300	7	ATExcp, ESSFxc

Appendix 3. Continued.

Location/coordinates	Altitude range	Observation hours	Biogeoclimatic zone
47. Silverhope Creek 49°07'N 121°22'W	1000	6	Hb, Mb
48. Shawatum Mtn 49°07'N 121°05'W	650	12	Ef
49. Mt Kobau 49°07'N 119°40'W	1800	13	MSxk, IDFdk
50. W of Duruisseau Ck 49°06'N 120°23'W	1300 -1700	8	ESSFxc
51. S of Nepopekum Mtn 49°03'N 121°00'W	600 -1500	16	Ef
52. Church Mtn 49°02'N 121°51'W	1000 -1250	4	Mb
53. Skyline Trail, Manning Park 49°02'N 120°55'W	1300 -1700	16	Ef, AEp
54. W of Mt Kruger 49°02'N 119°32'W	1000	6	IDFxh
55. Frosty Mtn 49°01'N 120°50'W	1300 -2400	19	AEp

Key to Biogeoclimatic Zones (based on Krajina 1959)

A. Vancouver Forest Region

AMp -undifferentiated alpine tundra and undifferentiated parkland mountain hemlock
AEp -undifferentiated alpine tundra and undifferentiated parkland Englemann spruce - subalpine fir
Ma -maritime forested mountain hemlock
Mb -submaritime forested mountain hemlock
Ee -dry southern forested Englemann spruce - subalpine fir
Ef -subcontinental forested Englemann spruce - subalpine fir
IFu -undifferentiated interior douglas fir
Hb5 -southern submaritime coastal western hemlock
Hc1 -drier maritime coastal western hemlock

B. Kamloops Forest Region

IDFxh -very dry hot interior douglas fir
IDFdk -dry cool interior douglas fir
MSxk -very dry cool montane spruce
MSdm -dry mild montane spruce
MS -undifferentiated montane spruce
ESSFxcp -very dry cold Englemann spruce - subalpine fir
ESSFdcp -dry cold Englemann spruce - subalpine fir
ESSFwm -wet mild Englemann spruce - subalpine fir
ATExcp -very dry cold alpine tundra Englemann spruce - subalpine fir parkland